Dist: A

(1)

FINAL/15 FEB 93 TO 14 FEB 94

NEXT GENERATION SOLID MODELLERS FOR ELECTRONI : PROTOTYPING

F49620-93-1-0149
2304/DS
61102F

DR. GUNZBURGER

University of Michigan
Mechanical Engineering
Ann Arbor, MI 48109

AFOSR/NM
110 DUNCAN AVE, SUTE B115
BOLLING AFB DC 20332-0001

F49620-93-1-0149

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

A

Methodologies for using the cyclide into solid modelling system to model complex blending surface and to assist in pipe layout have been developed.

UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED SAR(SAME AS REPORT)

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to **stay within the lines to meet optical scanning requirements.**

Block 1. Agency Use Only (Leave Blank)

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	- Contract	**PR**	- Project
G	- Grant	**TA**	- Task
PE	- Program Element	**WU**	- Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Names(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency. Report Number. (If known)

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of ..., To be published in .... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availablity Statement. Denote public availability or limitation. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR)

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
DOE - See authorities
NASA - See Handbook NHB 2200.2.
NTIS - Leave blank.

Block 12b. Distribution Code.

DOD - DOD - Leave blank
DOE - DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports
NASA - NASA - Leave blank
NTIS - NTIS - Leave blank.

Block 13. Abstract. Include a brief (Maximum 200 words) factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code (NTIS only).

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

Final Technical Report
AFOSR Grant # F49620-93-1-0149

Next Generation Solid Modellers for Electronic Prototyping

Debasish Dutta
Mechanical Engineering
University of Michigan
Ann Arbor, MI 48109
(313) 936-3567
Email: Dutta@engin.umich.edu

July 26, 1994

1. INTRODUCTION

In this research project, we are focusing on expanding the geometric coverage of solid modellers such that a wider variety of objects can be modelled accurately. Solid modellers are large computer programs that enable a designer to construct, interrogate and manipulate computer models of physical objects. They are at the core of every computer system for engineering analysis, prototyping, manufacture and inspection. Various manufacturing tasks can be simulated in the computer and electronic mock-ups (*i.e.* prototypes) can be created prior to actual manufacture.

The thrust of this project is to alleviate the geometric domain inadequacy of current solid modelers. Towards that end, we are investigating a new class of surface called the (Dupin) cyclide for incorporation into solid modelers. Cyclides have simple and intuitive geometric parameters, they can be represented in both implicit and parametric form, and their offset surfaces are easy to compute. All existing (CSG) solid modeling primitives (*i.e.*, plane, sphere, cylinder, cone and torus) are special cases of the cyclide giving rise to the possibility of a unified framework for surface interrogations, manipulations and intersections within a solid modeler. We have been working closely with Dr. Steve LeClair of the WPAFB in order to address issues of relevance to the Air Force. The applications listed above were

demonstrated to Dr. LeClair during his visit to our Design Laboratory at the University of Michigan.

2. RESEARCH RESULTS

In the previous year, we developed methodologies for using the cyclide in a solid modelling system to model complex blending surfaces, to assist in pipe layouts, and for synthesizing collision free volumes in 3D. This year, we focused on the design side of things, in that, an algorithm with a simple and effective user interface (we refer to as "circle composition) was developed that enables the construction of tubular surface pieces in 3D. It has been implemented on a Silicon Graphics Personal Iris workstation. Furthermore, on the applications domain, we addressed cable harness design and mold gate design using cyclides. Finally, portability issues of cyclide surfaces to commercial modelers, such as IDEAS, have been addressed. A brief description on each topic follows.

2.1 Circle Composition Scheme

In this project, we developed two synthesis algorithms and two surface editing algorithms. In the synthesis stage, a designer has a 2D user interface in which he can construct planar cross-sectional profiles of the tubular surface by simply putting together circles. In an adjoining window, the 3D surface is automatically generated. This 3D surface is composed of smoothly joined pieces of cyclides. The first algorithm preserves tangent continuity between adjacent pieces by using spherical surfaces. In the second algorithm, the spherical surface are eliminated and cyclide pieces are joined at their circular lines of curvature.

The first editing scheme of such tubular surfaces is enabled by moving one of the three defining spheres of the cyclide. In our implementation, the middle sphere is modified (position and/or size) to modify the entire shape. A more sophisticated method for surface editing has also been developed where double-cyclide blends are used to modify the surface. This provides a better local control of the surface.

2.2 Design of Mold Gates and Cable Harness

The circle composition scheme described above has been applied to two design probelms of interest to the Air Force (WPAFB). The first one is mold gate design. The program can effectively construct mold gates of circular cross section around the mold. A simple mold gate "feature" interface was also added that allows the designer to select and pick gating features such as the spout.

The second application of the composition scheme is in the area of cable harness. An important sub-problem in the design of aircrafts, the routing of cable wires, location of junction points and specification of bend radii are key features that a designer has to deal with. In our implementation, the circle composition scheme can be used as a first cut design tool to evaluate the proper placement of cable wires and junction points early in the design stage. It is easy to modify and manipulate.

2.3 Portability Issues

It is critical to acknowledge and address early on the portability of cyclide surfaces to other commercial modelers. Without a seamless "transfer" of cyclide models to and from commercial modelers, the effectiveness of cyclide surfaces in modeling will be compromised. Therefore, we have developed methods to transfer cyclide models to the commercial modeler IDEAS. Work is ongoing for a complete implementation.
